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Indian Standard
SPECIFICATION FOR BRAZING ALLOYS
(*First Revision*)

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Indian Standard

SPECIFICATION FOR BRAZING ALLOYS

(First Revision)

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Indian Standard
SPECIFICATION FOR BRAZING ALLOYS
(First Revision)

0. FOREWORD

0.1 This Indian Standard (First Revision) was adopted by the Indian Standards Institution on 1 May 1975, after the draft finalized by the Welding General Sectional Committee had been approved by the Structural and Metals Division Council.

0.2 This standard was first published in 1964 amalgamating IS : 24-1950* and IS : 192-1956†. The experience gained by the industry during recent years has necessitated this revision.

0.3 In this revision a few new alloys have been included to meet the requirements of the industry. Palladium bearing alloys and vacuum brazing alloys have also been covered. Some minor modifications have been effected in the composition of some of the alloys.

0.4 Some information for the guidance of consumers on classification and selection of brazing alloys is given in Appendix A.

0.5 For determining the fineness of granular or powdered material, the aperture sizes are based on IS : 460-1962‡. Where these sizes are not available other equivalent standard sieves may be used. For the purpose of comparison the corresponding sizes according to British Standard test sieves and sieves of the American Society for Testing and Materials are given in Appendix B.

0.6 This standard keeps in view the manufacturing and trade practices prevailing in the country in the field. Assistance has also been derived from the following publications:

BS 1845: 1966 Filler metals for brazing. British Standards Institution.

A-5.8-69 Brazing filler metals. American Society for Testing and Materials.

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*Specification for brazing solder (*revised*).
†Specification for silver solder (*revised*).
‡Specification for test sieves (*revised*).

0.7 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard covers brazing alloys employed in effecting a joint by the brazing process as defined in IS : 812-1957†. The standard covers the following types of brazing alloys:

a) Aluminium-silicon alloys,
b) Copper-and-copper-zinc alloys,
c) Copper-phosphorus alloys,
d) Copper-silver alloys,
e) Copper-gold alloys,
f) Magnesium-aluminium alloys,
g) Heat-resisting brazing alloys,
h) Palladium brazing alloys, and
j) Alloys for vacuum brazing.

2. SUPPLY OF MATERIAL

2.1 The general conditions regarding the supply and testing of materials shall be in accordance with IS : 1387-1967‡.

3. CHEMICAL COMPOSITION

3.1 Brazing alloys, when analyzed in accordance with appropriate Indian Standards, wherever available, shall have the chemical composition as shown in Tables 1 to 9.

3.1.1 A list of the Indian Standards already available on the chemical analysis of various metals is given below:

IS : 440-1964 Methods of chemical analysis of copper (*revised*)

IS : 504-1963 Methods of chemical analysis of aluminium and its alloys (*revised*)

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*Rules for rounding off numerical values (*revised*).

†Glossary of terms relating to welding and cutting of metals.

‡General requirements for the supply of metallurgical materials (*first revision*).

IS : 964-1956 Methods for chemical analysis of silver solder

IS : 999-1959 Methods of chemical analysis of brazing solder

IS : 4354 (Part I)-1967 Methods of chemical analysis of magnesium-aluminium brazing alloys: Part I Analysis of aluminium, manganese, zinc and silicon

IS : 4646 (Part I)-1968 Methods of chemical analysis of copper-phosphorus brazing alloys: Part I Analysis for silver and copper

IS : 4667 (Part I)-1968 Methods of chemical analysis of silver-copper brazing alloys: Part I Analysis for silver and copper

IS : 4667 (Part II)-1969 Methods of chemical analysis of silver-copper brazing alloys: Part II Determination of silver, copper and tin

IS : 4703-1968 Methods of chemical analysis of silver-manganese brazing alloys

3.1.2 Indian Standards dealing with the chemical analysis of other brazing alloys and the elements in the brazing alloys not so far covered are under preparation. Methods of chemical analysis of these shall be mutually agreed to between the purchaser and the supplier till the relevant standards are formulated.

4. MANUFACTURE

4.1 The brazing alloys may be manufactured by any method that will yield a product which will be of uniform quality and conform to the requirements of this standard.

NOTE — Brazing alloys containing gold or silver shall be preferably made from virgin metal or such clean scrap as may result from manufacture of the filler metal.

5. FREEDOM FROM DEFECTS

5.1 The brazing alloys shall be of uniform quality, clean, and free from foreign matters.

6. DIMENSIONS

6.1 The brazing alloys shall be normally supplied in the forms and sizes as given in Table 10.

6.2 Unless otherwise specified, the rods shall be supplied in lengths 500 and 1 000 mm.

6.3 Tolerances — The tolerances on diameter, side and thickness, as applicable to the sections of the products are given in Table 11. The tolerance on the length of rods shall be ±6 mm and the tolerances on weight of wires, the width and length of sheets and strips shall be mutually agreed to between the purchaser and the supplier.

7. PACKAGING

7.1 The brazing alloys shall be suitably wrapped, boxed or otherwise packed to protect these against damage during transport or under normal dry storage conditions.

8. MARKING

8.1 Packages or containers used for packing rods, powder, granules, formed shapes, coils or wire or strip shall be legibly labelled or tagged containing the following information:

a) Manufacturer's or supplier's name and trade designation and/or trade-mark;

b) Classification; and

c) Size, length (of rod), net weight.

8.1.1 Each container may also be marked with the Standard Mark

NOTE — The use of the Standard Mark is governed by the provisions of the Bureau of Indian Standards Act, 1986 and the Rules and Regulations made thereunder. The Standard Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well defined system of inspection, testing and quality control which is devised and supervised by BIS and operated by the producer. Standard marked products are also continuously checked by BIS for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

9. SAMPLING

9.1 A composite sample of 30 g from each lot of 50 kg or fraction thereof shall be taken. The sample so selected shall be representative of the lot.

9.1.1 Samples from rods, wire, strip or ingot shall be taken by sawing or by any other mechanical means through their entire cross section and thoroughly mixed. No lubricant shall be used when sawing or machining.

9.1.2 Samples of powder or granulated brazing alloys shall contain the grains as supplied.

TABLE 1 ALUMINIUM-SILICON BRAZING ALLOYS

(*Clause* 3.1)

CLASSIFICATION	CHEMICAL COMPOSITION, PERCENT											MELTING RANGE (APPROX)	
	Silicon	Copper	Iron	Zinc	Magnesium	Manganese	Chromium	Nickel	Aluminium	Other Element Each	Other Element Total	Solidus	Liquidus
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13) °C	(14) °C
BA Al Si 1	4·5-6·0	0·10	0·60	0·20	0·20	0·50	—	—	Remainder	0·05	0·15	565	630
BA Al Si 2	6·8-8·2	0·25	0·80	0·20	—	0·10	—	—	do	0·05	0·15	576	613
BA Al Si 3	10·0-13·0	0·10	0·60	0·20	0·25	0·50	—	0·20	do	0·05	0·15	565	595
BA Al Si 4	10·0-13·0	3·0-5·0	0·60	0·20	0·20	0·50	0·15	0·20	do	0·05	0·15	525	595

NOTE — Single values are maximum percentages.

TABLE 2 COPPER-AND-COPPER-ZINC BRAZING ALLOYS

(*Clause* 3.1)

CLASSIFICATION	CHEMICAL COMPOSITION, PERCENT															MELTING RANGE	
	Copper	Tin	Nickel	Iron	Manganese	Antimony	Phosphorus	Lead	Aluminium	Silicon	Bismuth	Arsenic	Zinc	Other Elements Each, *Max*	Other Elements Total, *Max*	Solidus	Liquidus
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
																°C	°C
BA Cu 1	99·90 *Min*	—	—	—	—	—	0·05	0·005	0·01	—	0·002 5	—	—	—	0·10	1085	1085
BA Cu Zn 1	79·0-81·0	0·10	—	0·15	—	0·05	—	0·50	—	—	0·05	—	Remainder	—	0·10	980	990
BA Cu Zn 2	59·0-61·0	0·10	—	0·15	—	0·05	—	0·50	—	—	0·05	0·05	do	—	0·10	885	890
BA Cu Zn 3	59·0-61·0	0·8-1·2	—	0·15	—	0·05	—	0·50	—	—	0·05	0·05	do	—	0·10	880	890
BA Cu Zn 4	57·0-63·0	0·50	—	0·1-0·5	0·05-0·25	0·05	—	0·03	0·03	0·20-0·30	0·05	0·05	do	—	0·30	870	900
BA Cu Zn 5	53·0-55·0	0·05	—	0·15	—	0·05	—	0·30	—	—	0·05	0·05	do	—	0·10	870	880
BA Cu Zn 6	53·0-55·0	0·8-1·2	—	0·15	—	0·05	—	0·30	—	—	0·05	0·05	do	—	0·10	860	870
BA Cu Zn 7	49·0-51·0	0·05	—	0·15	—	0·05	—	0·30	—	—	0·05	0·05	do	—	0·10	860	870
BA Cu Zn 8	45·0-53·0	0·5	8·0-11·0	0·5	0·5	—	0·25	0·03	0·03	0·20-0·50	—	—	do	—	0·50	920	980

NOTE — Single values are maximum percentages.

TABLE 3 COPPER-PHOSPHORUS ALLOYS

(*Clause* 3.1)

CLASSIFICATION	CHEMICAL COMPOSITION, PERCENT				MELTING RANGE (APPROX)	
	Phosphorus	Silver	Copper	Other Elements Total, *Max*	Solidus	Liquidus
(1)	(2)	(3)	(4)	(5)	(6)	(7)
					°C	°C
BA Cu P1	4·75-5·25	—	Remainder	0·15	710	924
BA Cu P2	7·00-8·25	—	do	0·15	705	800
BA Cu P3	6·00-7·00	1·80-2·20	do	0·15	645	740
BA Cu P4	5·80-6·50	4·80-5·50	do	0·15	643	807
BA Cu P5	4·50-5·00	14·50-15·50	do	0·15	643	802

TABLE 4 COPPER-SILVER BRAZING ALLOYS

(*Clause* 3.1)

CLASSIFICATION	CHEMICAL COMPOSITION, PERCENT							MELTING RANGE	
	Silver	Copper	Zinc	Cadmium	Nickel	Tin/Lithium	Other Elements Total, *Max*	Solidus	Liquidus
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
								°C	°C
BA Cu Ag 0	92-93	7-8	—	—	—	0·15-0·30 Li	0·15	780	890
BA Cu Ag 1	79-81	15-17	3-5	—	—	—	0·15	738	810
BA Cu Ag 2	74-76	21-23	2·5-3·5	—	—	—	0·15	741	788
BA Cu Ag 3	71-73	27-29	—	—	—	0·15-0·30 Li	0·15	780	780
BA Cu Ag 6	60-62	27·5-29·5	9-11	—	—	—	0·15	690	735
BA Cu Ag 7	59-61	29-31	—	—	—	9·0-11·0	0·15	600	720
BA Cu Ag 8	55-57	21-23	15-19	—	—	4·5-5·5	0·15	619	652
BA Cu Ag 8A	55-57	41·5-43·5	—	—	—	1·5-2·5	0·15	771	895
BA Cu Ag 8B	53-55	37·5-42·5	4-6	—	0·5-1·5	—	0·15	718	857
BA Cu Ag 9	49-51	33-35	14-18	—	—	—	0·15	688	774
BA Cu Ag 10	49-51	14-16	15-17	18-20	—	—	0·15	620	640
BA Cu Ag 11	49-51	14·5-16·5	14·5-18·5	17-19	—	—	0·15	627	635
BA Cu Ag 12	49-51	14·5-16·5	13·5-17·5	15-17	2·5-3·5	—	0·15	632	688
BA Cu Ag 14	44-46	29-31	23-27	—	—	—	0·15	677	743
BA Cu Ag 15	44-46	14-16	14-18	23-25	—	—	0·15	607	619
BA Cu Ag 16	42-44	36-38	18·5-20·5	—	—	—	0·15	700	775
BA Cu Ag 16A	42-44	15-17	18-22	20-22	—	—	0·15	615	620
BA Cu Ag 18	39-41	29-31	26-30	—	1·5-2·5	—	0·15	671	775
BA Cu Ag 19	37-39	19-21	21-23	19-21	—	—	0·18	605	650
BA Cu Ag 20	34-36	25-27	19-23	17-19	—	—	0·15	607	702
BA Cu Ag 21	29-31	26-28	21-25	19-21	—	—	0·15	607	710
BA Cu Ag 23	9-11	51-53	37-39	—	—	—	0·15	743	766

TABLE 5 COPPER-GOLD BRAZING ALLOYS

(*Clause* 3.1)

CLASSIFICATION	CHEMICAL COMPOSITION, PERCENT				MELTING RANGE	
	Gold	Copper	Nickel	Other Elements Total	Solidus	Liquidus
(1)	(2)	(3)	(4)	(5)	(6) °C	(7) °C
BA Cu Au 0	34·5-35·5	Remainder	2·5-3·5	0·15	974	1 030
BA Cu Au 1	37·0-38·0	do	—	0·15	991	1 016
BA Cu Au 2	79·5-80·5	do	—	0·15	880	880
BA Cu Au 3	81·5-82·5	do	—	0·15	949	949

TABLE 6 MAGNESIUM-ALUMINIUM BRAZING ALLOYS

(*Clause* 3.1)

CLASSIFICATION	CHEMICAL COMPOSITION, PERCENT									MELTING RANGE	
	Aluminium	Manganese	Zinc	Silicon	Copper	Nickel	Iron	Berylium	Magnesium	*Solidus	Liquidus
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11) °C	(12) °C
BA Mg Al 1	8·3-9·7	0·10	1·7-2·3	0·05	0·05	0·005	0·005	0·000 2 to 0·000 8	Remainder	443	599
BA Mg Al 2	11·0-13·0	—	4·5-5·5	—	—	—	—	0·000 2 to 0·000 8	do	410	568

*Other elements total = 0·30 percent for each of the alloys.

TABLE 7 HEAT-RESISTING BRAZING ALLOYS

(*Clause* 3.1)

Classification	Chemical Composition, Percent								Melting Range	
	Nickel	Chromium	Boron	Silicon	Iron	Carbon	Phosphorus	Other Elements Total, *Max*	Solidus	Liquidus
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
									°C	°C
BA HR Ni 1	Remainder	13·0-15·0	2·75-4·00	3·0-5·0	4·0-5·0	0·6-0·9	—	0·50	977	1038
BA HR Ni 2	do	6·0-8·0	2·75-3·50	4·0-5·0	2·0-4·0	0·15	—	0·50	971	999
BA HR Ni 3	do	—	2·75-3·50	4·0-5·0	1·5	0·06	—	0·50	982	1038
BA HR Ni 4	do	—	1·0-2·2	3·0-4·0	1·5	0·06	—	0·50	988	1065
BA HR Ni 5	do	18·0-20·0	—	9·75-10·5	—	0·15	—	0·50	1080	1135
BA HR Ni 6	do	—	—	—	—	0·15	10·0-12·0	0·50	877	877
BA HR Ni 7	do	11·0-15·0	—	—	—	—	9·0-11·0	0·50	888	888

NOTE 1 — Single values shown are the maximum percentage.

NOTE 2 — Analysis shall be made for the elements for which specific values are shown in tables. Should however the presence of other elements is indicated in the course of routine analysis, further analysis shall be made to determine these elements and the total of these other elements present shall not exceed the limit specified for other elements in the last column of the tables.

NOTE 3 — A range of palladium bearing alloys that have been developed is also finding increasing application in other countries. Table 8 gives a series of palladium bearing alloys and their melting ranges.

TABLE 8 PALLADIUM BEARING BRAZING ALLOYS

(*Clause* 3.1)

CLASSIFICATION	CHEMICAL COMPOSITION, PERCENT					MELTING RANGE	
	Silver	Copper	Palladium	Manganese	Nickel	Solidus	Liquidus
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
						°C	°C
BA Cu PD 1*	68·0-69·0	26·0-27·0	4·5-5·5	—	—	805	810
BA Cu PD 2*	58·0-59·0	31·0-32·0	9·5-10·5	—	—	825	850
BA Cu PD 3*	67·0-68·0	22·0-23·0	9·5-10·5	—	—	830	860
BA Cu PD 4*	64·5-65·5	19·5-20·5	14·5-15·5	—	—	850	900
BA Cu PD 5*	51·5-52·5	27·5-28·5	19·5-20·5	—	—	875	900
BA Cu PD 6*	53·5-54·5	20·5-21·5	24·5-25·5	—	—	900	950
BA Cu PD 7	94·5-95·5	—	4·5-5·5	—	—	970	1 010
BA Cu PD 8	—	81·5-82·5	17·5-18·5	—	—	1 080	1 090
BA Cu PD 9	74·5-75·5	—	19·5-20·5	4·5-5·5	—	1 000	1 120
BA Cu PD 10	63·5-64·5	—	32·5-33·5	2·5-3·5	—	1 180	1 200
BA Cu PD 11	—	—	20·5-21·5	30·5-31·5	47·5-48·5	1 120	1 120
BA Cu PD 12	—	54·5-55·5	19·5-20·5	9·5-10·5	14·5-15·5	1 060	1 110
BA Cu PD 13	—	34·5-35·5	29·5-30·5	14·5-15·5	19·5-20·5	1 070	1 090
BA Cu PD 14*	—	—	59·5-60·5	—	39·5-40·5	1 235	1 235

*If lithium is present, not as an impurity, it shall be within the range 0·35 percent to 0·68 percent. For some specialized applications certain elements having a high vapour pressure have to be excluded. In these special cases specific maximum levels of such impurity shall be agreed to between the supplier and the purchaser.

TABLE 9 ALLOYS FOR VACUUM BRAZING APPLICATIONS

(*Clause* 3.1)

CLASSIFICATION	CHEMICAL COMPOSITION			REMARK
	Main Constituent	Impurities	Parts per Million (ppm), *Min*	
(1)	(2)	(3)	(4)	(5)
BA Cu Ag 3V	As type BA Cu Ag 3	Bismuth	10	
		Cadmium	10	
		Lithium	30	
		Zinc	10	
		Carbon	40	
		Impurity limits apply to all types		
BA Cu PD 1V	As type BA Cu PD 1	Aluminium	5	100 approx in the case of PD 14 V
BA Cu PD 2V	As type BA Cu PD 2	Beryllium	5	
BA Cu PD 3V	As type BA Cu PD 3	Chromium	10	
BA Cu PD 4V	As type BA Cu PD 4	Titanium	10	
BA Cu PD 5V	As type BA Cu PD 5	Zirconium	5	
		Carbon	50	
BA Cu PD 6V	As type BA Cu PD 6	Phosphorus	100	
BA Cu PD 7V	As type BA Cu PD 7	Antimony	30	The total of these impurities shall not exceed 90 ppm
BA Cu PD 8V	As type BA Cu PD 8	Bismuth	10	
BA Cu PD 14V	As type BA Cu PD 14	Cadmium	10	
		Calcium	30	
BA Cu Au 2V	As type BA Cu Au 2	Lead	20	
BA Cu Au 3V	As type BA Cu Au 3	Lithium	30	
		Magnesium	30	
		Zinc	10	

NOTE — The above table gives the impurities in respect of certain alloys whose main constituents are specified in other tables, when they are to be used on vacuum brazing applications. When ordering an alloy to comply with the requirements of this table the letter 'V' shall be added to the alloy type.

TABLE 10 STANDARD FORMS AND SIZES

(*Clause* 6.1)

CLASSIFICATION (1)	STANDARD FORM (2)	SIZES (3)
BA Al Si 1	Wire in coils, Rod in length	Round 2·5, 3·15, 4·0, 5·0, 8·0 mm
BA Al Si 2	Strip	Thickness 0·25, 0·50 mm
BA Al Si 3	Wire in coils, Rod in length	Round 1·6, 2·5, 3·15, 4·0, 6·3 mm
BA Al Si 4	Strip	Thickness 0·25, 0·50 mm
BA Cu 1	Wire in coils, Rod in length	Round 1·6, 2·5, 3·15, 4·0 and
BA Cu 1	Strip	Thickness 0·25, 0·50 mm
BA Cu Zn 1	Wire in coils, Rod in length	Round 1·0, 2·5, 3·15, 4·0 and 5
BA Cu Zn 2	Strip	Thickness 0·25, 0·50 mm
	Powder	Powder 425, 180, 125, 75, 45 m
BA Cu Zn 3 BA Cu Zn 4 and BA Cu Zn 5	Rod	Round 1·0, 1·5, 2·5, 3·15, 6·3 mm Square 8·0, 10 mm
BA Cu Zn 6 BA Cu Zn 7 BA Cu Zn 8	Strip Wire in coils	Sizes shall be furnished acco customers' requirements su manufacturers limitations
BA Cu P 1	Strip	Thickness 0·12, 0·25, 0·38 × 4
BA Cu P 2 and BA Cu P 3	Wire in coils	Round 1·0, 1·5, 2·5 mm
	Rod	Round 1·5, 2·5, 3·15, 4·0 and 6 Square 3·15, 5·0 and 6·3 mm
	Powder	Powder 150, 45 microns
	Wire in coils	Round 1·0, 1·5 and 2·5 mm
BA Cu P 4	Rod	Round 1·5, 2·5, 3·15, 5·0 and 6 Square 2·5, 3·15, 4·5 and 6·13
	Strip	Thickness 0·12, 0·25, 0·38 × 2
	Powder	Powder 850, 150, 75, 45 micron
BA Cu P 5	Strip	Thickness 0·08, 0·12, 0·25, 0·6 of 6·3 mm up to 15 cm
	Wire in coils	Round 0·75, 1·0, 1·5 and 2·5 m
	Powder	Powder 850, 150, 75, 45 micro
BA Cu Ag 0 to BA Cu Ag 23	Strip	Strip 0·08, 0·12, 0·25, 0·5 in 6·3 mm with a maximum of 1
	Wire in coils	Round 0·75, 1·0, 1·5 and 2·5
	Powder	Powder 850, 150, 75, 45 micron
BA Cu Au 0 to BA Cu Au 3	Strip Wire on coils	To order
BA Mg Al 1 and BA Mg Al 2	Wire in coils Rod in length	Round 1·5, 2·5, 3·15, 4·0 and
BA HR Ni (all classifications)	Wire in coils	Round 0·50, 0·75, 1·5 and 3·15
	Rod	Square 3·15 × 250 mm
	Strip	Thickness 0·38 × 19·0, 0·50 ×
	Powder	45 microns

TABLE 11 PERMISSIBLE VARIATION IN DIMENSIONS

(*Clause* 6.3)

Standard Form	Size	Permissible Variation	
		Round	Square
(1)	(2)	(3)	(4)
		mm	mm
	a) *For Wire and Rod* (mm)		
Drawn wire diameter (round) or width (square)	0·25 to 0·50	±0·007	—
	Over 0·50 to 0·75	±0·015	—
	” 0·75 to 1·0	±0·018	—
	” 1·0 to 1·25	±0·020	—
	” 1·25 to 1·60	±0·025	—
	” 1·60 to 2·0	±0·036	—
	” 2·0 to 8·0	±0·050	±0·10
Drawn rod diameter (round)	4·0 and under	±0·07	—
	5 and over	±0·10	—
Rolled or extruded wire and rod diameter or width (square)	0·75 to 1·5	±0·12	—
	Over 1·5 to 3·0	±0·15	—
	” 3·0 to 5·0	±0·18	±0·23
	” 5·0 to 8·0	±0·20	±0·25
	b) *For Strip 200 mm and Under in Width**		
	Thickness	Variation in Thickness	
Strip or sheet	0·15 and under	±0·015	
	Over 0·15 to 0·30	±0·025	
	” 0·30 to 0·50	±0·031	
	” 0·50 to 0·66	±0·050	

Sizes for granular or powdered alloys IS Sieve through which grains shall pass:

	mm	*Microns*
850 micron	0·850	±50
425 micron	0·425	±25
180 micron	0·180	±14
150 micron	0·150	±10
125 micron	0·125	± 9
75 micron	0·075	± 6
45 micron	0·045	± 5

Note — In special cases, it may be specified that the grains of the alloys shall pass through one of the sieves included in the table but shall be retained on the next immediate smaller sieve.

BS and ASTM test sieves given in Appendix B have their apertures within the limits specified for IS Sieves given in this table and may, therefore, be used as Indian Standard Test Sieves.

*For over 200 mm in width, standard strip and sheet tolerances apply.

APPENDIX A

(*Clause* 0.4)

CLASSIFICATION AND SELECTION OF BRAZING ALLOYS

A-0. GENERAL

A-0.1 This appendix has been prepared as an aid to the users of brazing alloys and to help them in determining the classification or the type of brazing alloy best suited for a particular job. Brazing is a process in which a non-ferrous filler metal having a melting point above 427°C but lower than that of the base metal is used and is distributed between closely fitted surfaces by capillary attractions. Brazing operation is carried out by the following processes:

a) Torch brazing,
b) Furnace brazing,
c) Dip brazing — phosphorus alloys (with and without silver),
d) Induction brazing,
e) Resistance brazing,
f) Flow brazing,
g) Block brazing, and
h) Twin — carbon arc brazing.

A-1. CLASSIFICATION

A-1.1 Brazing alloys are now available in increasing varieties and may be classified into nine main groups, as given in this specification. These groups are:

a) Aluminium-silicon alloys,
b) Copper-and-copper-zinc alloys,
c) Copper-phosphorus alloys (with and without silver),
d) Copper-silver alloys,
e) Copper-gold alloys,
f) Magnesium-aluminium alloys,
g) Heat-resisting brazing alloys,
h) Palladium brazing alloys, and
j) Alloys for vacuum brazing.

A-1.2 The nine basic groups of classifications of brazing alloys are identified as shown in Tables 1 to 9 of this standard by the principal element or elements in their chemical composition. In a typical example, such as BA Cu Ag 1, the first two letters ' BA ' stand for ' brazing alloys ' and the next two groups of letters ' Cu ' and ' Ag ' indicate that the principal elements in this brazing alloys are copper and silver (in a similar way in other brazing alloys, Al is for aluminium, Si is for silicon, P is for phosphorous, etc these being standard chemical symbols). The number '1' is for one particular composition within a group (2 is another analysis within the same group and 3 being another composition).

A-2. SOLIDUS AND LIQUIDUS TEMPERATURES

A-2.0 The terms solidus and liquidus, instead of melting and flow points have been used as the two letter terms have not been always used with the same meaning, resulting in confusion. The terms solidus and liquidus are well established in metallurgical usage and their definitions are as follows:

Solidus — The highest temperature at which the metal is completely solid.

Liquidus — The lowest temperature at which the metal is completely liquid.

The solidus and liquidus of a particular metal or alloy are definite and fixed. On the other hand melting point (particularly for certain types of alloys) and flow point tend to be ambiguous.

Generally these two terms are defined as under:

Melting Point — The temperature below which the alloy is substantially solid.

Flow Point — The temperature above which the alloy is liquid and will run or flow.

However, these definitions are often not followed and are not in themselves very definite. In this specification the solidus and the liquidus temperatures of the various brazing alloys have been listed along side their chemical composition.

A-2.1 Some brazing alloys particularly those with a wide temperature range between solidus and liquidus have several constituents in the filler metal and these tend to separate during the melting process; the lower melting constituent will flow out leaving a ' skull ' of the high melting constituent. Separation of the solid and liquid portions in this manner is called ' liquation ' and is undesirable since the unmelted skull does not contribute significantly to the efficiency of the brazed joint. If, however, the work piece is heated rapidly through the melting range to a temperature above the liquidus, there would be little time for liquation to take place and the filler metal will remain homogeneous as it flows through the joint, but on the other hand, where fit up is not too good a filler metal with a wide temperature range will usually fill the joint more easily.

A-2.2 A brazing alloy wets the base metal on which it is applied and, therefore, a diffusion of the alloy into the base metal or the dilution of the alloy by the base metal may occur, the latter particularly when there exists a similarity in composition between the brazing alloy and the base metal. The factors which may influence the extent of diffusion are, (a) the brazing temperature, (b) the length of the brazing cycle, (c) the geometry of the joint being brazed, and (d) the chemical composition of the alloy. Excessive diffusion of an alloy into the base metal may effect its physical and mechanical properties. In order to reduce either dilution or diffusion by an alloy, the brazing cycle should be kept low and within the melting range recommended for the brazing alloy used.

A-2.3 When brazing with any of the various processes, pre-braze cleaning of the base metal particularly the joint and the adjacent area, is essential, the surface should be free of grease and oil, oxides, scales and dirt of any kind. Cleaning can be done either mechanically or chemically. Oil or grease can be removed by the use of suitable degreasing solvent. Oxides and scales can be removed by a chemical bath or mechanically, after degreasing.

Joint clearance, that is, the dimension between the interfaces of the completed brazed joint, has a direct bearing on the mechanical strength of any brazed joint.

Table 12 recommends joint clearances at brazing temperature for various types of brazing alloys.

TABLE 12 RECOMMENDED JOINT CLEARANCES AT BRAZING TEMPERATURE

CLASSIFICATION (1)	JOINT CLEARANCE (2)
BA Al Si Group	0·15 to 0·25 for length of lap less than 6·5 0·25 to 0·65 for length of lap greater than 6·5
BA Cu 1	0·00 to 0·05
BA Cu Zn Group	0·05 to 0·12
BA Cu P Group	0·05 to 0·12
BA Cu Ag Group	0·05 to 0·12
BA Cu Au Group	0·05 to 0·12
BA Mg Al Group	0·10 to 0·25
BA HR Ni Group	0·05 to 0·12

NOTE — In the case of round or tubular members this means a clearance as the radius.

A-3. OPERATING CHARACTERISTICS AND USES

A-3.1 BA Al Si (Aluminium-Silicon) Brazing Alloys — Brazing alloys of BA Al Si classifications are used for joining the various grades of brazeable aluminium and aluminium alloys.

BA Al Si 1 — General purpose brazing alloy is recommended for torch, dip and furnace brazing.

BA Al Si 2 — Brazing alloy is made only as a cladding on N3 and H10 (*see* IS : 737-1965*) aluminium alloy core sheet, coated on one or both sides, suitable for dip, and furnace brazing.

BA Al Si 3 — General purpose brazing alloy specially recommended for cases where relatively high corrosion resistance properties are required and is suitable for torch brazing, but may also be used for furnace and dip brazing.

BA Al Si 4 — General purpose brazing alloy is recommended for torch, dip and furnace brazing. This brazing alloy is not recommended for brazing food containers and utensils.

A-3.2 BA Cu and BA Cu Zn (Copper and Copper Zinc) — Brazing alloys of the BA Cu and BA Cu Zn classification are used for joining various ferrous and non-ferrous metals. These can be used with various brazing processes.

BA Cu 1 — Brazing alloy is used for joining ferrous metals, nickel and copper-nickel alloys. It is very free-flowing when liquid and is widely used, generally without flux, for furnace brazing in a hydrogen or dissociated ammonia (reducing) atmosphere.

BA Cu Zn 1 — Brazing alloy is used for brazing steel parts which are subjected to heat treatment after brazing.

BA Cu Zn 2 and 3 — Brazing alloys are suitable for brazing brass and other copper alloys, nickel, malleable iron, galvanized mild steel and steel. It is tough, durable, strong and easy to apply.

BA Cu Zn 4 — Similar application as BA Cu Zn 2. The presence of tin in this alloy is advantageous for torch brazing since it reduces the tendency for zinc to volatalize from the molten brazing alloy.

BA Cu Zn 5 — Brazing alloy is for general purpose use.

BA Cu Zn 6 — Brazing alloy is for general purpose torch brazing.

BA Cu Zn 7 — Brazing alloy commonly known as 'spelter' is used generally in granular form for hearth brazing. The joints in this case tend to be brittle.

BA Cu Zn 8 — Brazing alloy commonly known as 'white brass' is suitable for brazing steels, nickel and nickel alloys with all the brazing processes.

A-3.3 BA Cu P (Copper-Phosphorus) Brazing Alloys — Brazing alloys of the BA Cu P classification are primarily used for joining copper and copper alloys with some limited use on silver and molybdenum. Since

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*Specification for wrought aluminium and aluminium alloys, drawn tube (for general engineering purposes) (*revised*). (Since revised).

brazing alloys of this classification contain phosphorus which will form brittle iron and nickel phosphites, these alloys are not recommended for ferrous and nickel bearing metals. With most of these brazing alloys, copper and silver can be brazed without the use of the flux. However, for brazing copper alloys flux may be necessary.

BA Cu P 1 — Brazing alloy is used primarily for replacing in the joint and is suited particularly for resistance brazing and some furnace brazing applications. This alloy is more ductile than the other alloys in this group.

BA Cu P 2 — Brazing alloy is extremely fluid at the brazing temperature. It will penetrate joints with very little clearance.

BA Cu P 3 — Brazing alloy, which is also a copper-silver phosphorus alloy has a high fluidity.

BA Cu P 4 — Brazing alloy is similar to BA Cu P 3 but is best used with lower joint clearance.

BA Cu P 5 — Brazing alloy is similar to BA Cu P 4 alloy and is particularly adaptable when close fit cannot be held.

A-3.4 BA Cu Ag (Copper-Silver) Brazing Alloys — Brazing alloys of the BA Cu Ag classification are used for joining all ferrous and non-ferrous metals excepting aluminium, magnesium and other metals which have too low a melting point. These brazing alloys are free-flowing when molten and are used with all the brazing processes.

BA Cu Ag 0 — Brazing filler metal is suitable for pure dry atmosphere brazing and is of particular advantage when brazing precipitation-hardening and other stainless steels in 760°C to 370°C range. The lithium content serves to promote wetting and to increase the flow of the filler metal on difficult to braze metals and alloys and this alloy is usually used where the precipitation-hardening heat treatment is combined with the brazing operation.

BA Cu Ag 1 and 3 — Brazing alloys are used in assembling of vacuum tubes, where volatile elements are not permitted to be used. Although these alloys are free-flowing, these do not wet well on ferrous metals. The colour after brazing is white.

BA Cu Ag 2 — Is generally used for joining sterling silver. The colour after brazing is white.

BA Cu Ag 6 — Brazing alloy is particularly suitable for joining electrical components requiring high electrical conductivity and gives a close colour match on silver.

BA Cu Ag 7 — Brazing alloy often known as ' silversmiths solder ' is particularly suitable for brazing small parts and is corrosion-resisting and ductile.

BA Cu Ag 8 — Brazing alloy is a low melting filler metal and does not contain cadmium. It is good for furnace brazing and is whitish in colour, after brazing gives a closer match with whitish metals, such as stainless steel. It is used by the dairy and food industry where cadmium free joints are required. This brazing alloy is less prone to cause stress cracking on stainless steel and some nickel alloys.

BA Cu Ag 8 B — Brazing alloy is used for service temperature up to 371°C. Its low zinc content makes it suitable for furnace brazing.

BA Cu Ag 8 A — Is similar to BA Cu Ag 8 B except that it contains no zinc. This is an advantage where zinc volatalization is objectionable in furnace operations.

BA Cu Ag 9, 14 and 16 — Brazing alloys are general purpose brazing alloys for use at higher brazing temperatures. They may be used where the use of a brazing alloy containing cadmium, as for food handling or processing equipment, is objectionable.

BA Cu Ag 10, 11 and 15 — Brazing alloys are for general purpose work and are free-flowing with narrow melting ranges.

BA Cu Ag 12 — Brazing alloy is particularly suitable for brazing carbide tool tips to tool shanks as it wets the carbide tool tip very satisfactorily. It has a wide wetting range and, therefore, the solid and the liquid portions do not tend to separate excessively. It is a good filler metal for bridging gap. It has good corrosion resistant properties and is particularly suitable for brazing stainless steel also.

BA Cu Ag 16 A — Brazing alloy can be used in brazing operation requiring a low temperature, quick and complete penetration, and neat joints of high strength that need little or no finishing. It is essentially an alloy for use where joints are closely fitted or where it is desired to employ a single brazing alloy that will be effective in wide range of applications. It can be used in brazing steel, copper, brass, gunmetal tin bronzes, aluminium and manganese bronzes, copper nickel alloys and nickel silver of all types.

BA Cu Ag 18 — Brazing alloy is used for carbide tip brazing, similar to BA Cu Ag 12, but higher brazing temperature is required.

BA Cu Ag 19, 20 and 21 — Brazing alloys are free-flowing and are suitable for general purpose work requiring slightly higher brazing temperature. Whilst their melting ranges are helpful where joint clearances are not uniform, these brazing filler metals may tend to liquate unless proper care is taken.

BA Cu Ag 23 — These are suitable for brazing ferrous and non-ferrous metals not damaged by temperatures required.

A-3.5 BA Cu Au (Copper-Gold) Brazing Alloys — Brazing alloys of the BA Cu Au classification are mainly used for brazing of iron, nickel and cobalt base metals where resistance to oxidation or corrosion is required. Bacause of their low rate of interaction with the base metal, they are commonly used on thin base metals. These filler metals are usually used with induction, furnace or resistance heating in a reducing atmosphere or in a vacuum and with no flux. For other applications a borax-boric acid flux is used.

BA Cu Au 0 — BA Cu Au 1 and BA Cu Au 2 brazing alloys when used for different joint, in the same assembly, permit variation in brazing temperature so that step brazing can be used.

BA Cu Ag 3 — Brazing alloy is used to braze a wide range of iron and nickel base alloys.

A-3.6 BA Mg Al (Magnesium Aluminium) Brazing Alloys

BA Mg Al 1 — Brazing alloy of this classification is used for joining aluminium magnesium base metal. It is generally used with torch and dip brazing processes but not by the resistance brazing.

BA Mg Al 2 — This has similar uses as BA Mg Al 1, but for its lower melting range is usually preferred in most brazing applications. Heating shall be closely controlled with all filler metals to prevent melting of the base metal. A flux is used with all processes.

A-3.7 Heat-Resisting Brazing Alloys — The BA HR N filler metals are particularly suited to vacuum systems and vacuum tube applications because of their very low vapour pressure. The limiting element is chromium in those alloys in which it is employed. No silver, copper, zinc or other high vapour pressure elements are employed. It should be noted that when phosphorus is combined with some other elements, these compounds have very low vapour pressures and can be readily used in vacuum brazing atmosphere of 0·1 μ of mercury at 7 066°C without removal of phosphorus.

BA HR Ni 1 — Brazing alloy can be widely used for high strength and heat-resistant joints, for example, in joining turbine blades, jet engine parts, highly stressed sheet metal structures and other highly stressed components.

BA HR Ni 2 — Has properties and uses which are similar to BA HR Ni 1, except that brazing can be conducted at lower temperatures with better flow and diffusion.

BA HR Ni 3 — Alloy is a good heat-resistant metal for lower temperature brazing of highly stressed parts. It is used for applications similar to BA HR Ni 1 and will flow well in marginal atmospheres or where joints of close tolerances or large areas are encountered.

BA HR Ni 4 — Is similar to BA HR Ni 3 and is used for forming larger, more ductile fillets. It can be used to form joints where fairly large gaps are present.

BA HR Ni 5 — Is used for high strength and oxidation-resistant joints for elevated temperature service, its applications are similar to BA HR Ni 1 except that it can be used in certain nuclear applications where boron cannot be tolerated.

BA HR Ni 6 — Brazing filler metal is extremely free flowing and exhibits a minimum amount of erosion with most nickel and iron base metals. It is good for use in marginal atmospheres and for brazing low chromium steels in exothermic atmospheres.

BA HR Ni 7 — Alloy is used for the brazing of honey comb structures, thin walled tube assemblies and other structures which are used at high temperature. Erosion can be controlled because of low solubility with iron and nickel base alloys. It produces strong, leak-proof joints with heat-resistant base metals at relatively low brazing temperatures. It is recommended for nuclear applications where boron cannot be used. The best results are obtained when it is used in the furnace brazing process. Ductility is improved by increasing time at brazing temperature.

A-3.8 Palladium Bearing Brazing Alloys — Alloys of this group, based on copper-silver-palladium system are widely used in electronic industries. Nickel-manganese-palladium, copper-palladium-nickel-manganese, palladium-nickel and nickel-chromium-palladium-silicon alloys are used for brazing stainless and other heat-and-corrosion-resisting alloys.

The nickel-manganese-palladium and the nickel-chromium-palladium-silicon alloys are particularly suitable for brazing heat and corrosion resisting materials in the form of thin sheet where a minimum of base metal erosion during the brazing cycle is required, both alloys being beneficially used in conjunction with furnace brazing technique under vacuum and dry hydrogen atmosphere. The palladium containing brazing alloys generally exhibit good flow and gap-filling characteristics coupled with relatively little tendency to erode the common iron and common iron and nickel base alloys during the brazing operations.

A-4. ELEVATED SERVICE TEMPERATURES

A-4.1 All metals and alloys lose strength as the temperature increases and brazing alloys are no exception. It will, therefore, be appreciated that brazed joints can' be expected to lose strength as temperature increases. It should also be understood that rules as to the maximum operating temperature that a brazed joint will stand are complex, particularly when so many base metals and filler metals are involved. In addition, careful consideration should be given to oxidation of the brazing filler metal in the joint as oxidation may occur both internally and at the joint surface. In the circumstances the subject may be treated only in a general manner.

A-4.2 Since little data is available on tensile tests, creep and stress rupture tests, the design should take into consideration the lower load capacity of the joint, when it is designed for service at elevated temperature. The best course of action would be to test sample joints under actual service conditions which may be the only method of predicting the service life.

A-4.3 At the same time it should be well understood that the solidus and liquidus are no guide to maximum service temperature of the brazing alloy. Table 13 lists the suggested maximum service temperatures for various brazing alloys, but these are based on different concept of design. The same factors, which are considered for selecting the base metals, should also be applied for selecting the brazing alloy for elevated temperature service.

TABLE 13 SUGGESTED MAXIMUM SERVICE TEMPERATURE FOR VARIOUS BRAZING ALLOYS

CLASSIFICATION (1)	SUGGESTED LIMITED SERVICE TEMPERATURE FOR CONTINUOUS SERVICE (2) °C	SUGGESTED SERVICE TEMPERATURE, *Max* (3) °C
BA Cu P Group	149	149
BA Cu Group	204	482
BA Cu Zn Group	204	260
BA Cu Ag Group	204	260
BA HR Ni Group	538	1 093

NOTE — Where stress and time will permit, the suggested maximum service temperatures are applicable.

APPENDIX B

(*Clause* 0.5)

COMPARATIVE DESIGNATION OF IS, BS AND ASTM TEST SIEVES

IS Test Sieve	*BS Test Sieve*	*ASTM Test Sieve*
850 micron	18	840 µ (20)
425 ,,	36	420 µ (40)
180 ,,	85	177 µ (80)
150 ,,	100	149 µ (100)
125 ,,	120	125 µ (120)
75 ,,	200	74 µ (200)
45 ,,	350	44 µ (325)

(*Continued from page* 2)

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(First Revision)

Addendum

(*Page 5, clause 5.1*) - Add the following new Note after 5.1:

'NOTE - The melting ranges of the filler metals given in the Tables 1 to 10 are for general information only.'

(SMDC 14)

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